Assessment of Childhood Cancer Incidence Cape Cod, Massachusetts

Prepared by

Bureau of Environmental Health Assessment
The Environmental Public Health Center
and Environmental Epidemiology Unit
September 1999

Abstract

This report presents an evaluation of cancer among children (ages up to and including 19 at time of diagnosis) on Cape Cod, Massachusetts. All cancers diagnosed in children between 1982 and 1994 and reported to the Massachusetts Cancer Registry (MCR) are included. The purpose of the evaluation was to describe the types of cancer that were occurring among Cape Cod children and to identify areas with a greater than expected occurrence of childhood cancer. The investigation was initiated at the request of a Cape Cod citizen who was concerned that childhood cancer might be a problem on Cape Cod and believed that the cancer incidence should be characterized to determine if a problem existed.

Each cancer case was geocoded to identify the location of the child. s residence at time of diagnosis. Standardized Incidence Ratios (SIRs) were calculated to estimate whether the number and types of cancers diagnosed among children were different from what was expected based upon state childhood cancer rates. Information was not available from the MCR on potentially important factors such as length of residence, residences prior to diagnosis, and potential adverse environmental and non-environmental exposures.

There were 101 cancers diagnosed among children on Cape Cod between 1982 and 1994. Overall, this figure represents 19 percent more cancer than would have been expected (10 excess cases in females and 6 in males). The three most common types of cancer diagnosed were lymphomas, leukemias, and central nervous system tumors. The observed elevation in total cancer was mostly due to elevations in lymphomas and leukemia among Mid-Cape children and, to a lesser extent, leukemia among Lower-Cape. Childhood cancer did not appear to concentrate in specific areas within towns or within specific time periods. In addition, the types of cancer most commonly observed and the ages at diagnosis generally followed a pattern observed elsewhere in the state. Although more cancer of certain types of cancer were found in a few areas, the results did not suggest a common environmental factor as being responsible for the excess.

This report was supported, in part, by funds from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) trust fund provided to the Massachusetts Department of Public Health from the Agency for Toxic Substances and Disease Registry (ATSDR), Public Health Service, U.S. Department of Health and Human Services.

Table of Contents

I. INTRODUCTION

At the request of a Cape Cod resident, the Environmental Epidemiology Unit and the Environmental Public Health Center of the Massachusetts Department of Public Health, Bureau of Environmental Health Assessment (MDPH, BEHA) conducted an evaluation of cancer incidence among children on Cape Cod, Massachusetts. The request pertained to rates of cancer among children on Cape Cod, as well as to information about the causes of childhood cancer with particular interest in leukemia.

This report analyzes descriptive health data to determine whether an elevated rate of cancer exists among children on Cape Cod and specifically describes the following:

1) The number of Cape Cod children diagnosed with particular types of cancer from 1982-1994.

2) The expected number of cancers based on age-adjusted statewide data, and the types of cancers elevated on Cape Cod.

3) The geographic distribution of cancer at the town level on Cape Cod.

Information from these descriptive analyses can identify areas where further public health investigation may be warranted. The descriptive nature of the data does not permit conclusions to be drawn about the possible causes of elevated rates of cancer on Cape Cod.

II. CANCER INCIDENCE ANALYSIS FOR CAPE COD

A. METHODS

This report includes all childhood cancers among Cape Cod children reported to the Massachusetts Cancer Registry (MCR) between 1982 and 1994. Cancers reported to MCR are incident cancers, meaning newly diagnosed cancers. The MCR collects reports of all newly diagnosed cancer cases from all Massachusetts acute care hospitals. Reciprocal reporting agreements exist with nine states, including Alaska, Arkansas, Connecticut, Florida, New Hampshire, New York, Rhode Island, and Maine. Cancer can appear to be very common in a community, particularly for cancers with a high survival rate, even if the incidence of cancer is not elevated compared to what might be expected in relation to the statewide incidence of cancer. As survival from cancer has increased in this country over the past several decades, the prevalence of cancer in our communities has increased as well.

The term cancer is used to describe a variety of diseases associated with abnormal cell and tissue growth. Histology (cell type) and primary site (location in the body where the disease originated) classify these different diseases. Epidemiological studies have revealed that different histologic types of cancer are individual diseases generally with separate causes, risks, characteristics and patterns of survival (Chow et al. 1996).

Childhood, for the purposes of this report, is defined as the period from birth up to and including 19 years of age. Childhood cancer on Cape Cod is defined as any reportable cancer diagnosed in a Cape Cod resident, aged 19 years or younger for the period 1982 through 1994.

The childhood cancers are divided into 8 groups based on the etiology and behavior (i.e. benign, in-situ, malignant, metastatic) of the cancers (Birch and Marsden, 1987). These groups were developed for childhood cancer because cancers in children tend to be similar due to their histological type (morphology), rather than solely due to their primary site of origin (i.e., lung, prostate, or colon). The authors of this category system point out that "some typical childhood tumors, e.g., rhabdomyosarcoma, can occur virtually anywhere in the body" (Birch and Marsden, 1987, page 620). Childhood tumors tend to arise from particular tissue types (blood and lymph systems, central nervous systems, soft tissue, bone tissue and viscera). Furthermore, the most common childhood cancers are usually diagnosed in the first few years of life. The ICD-O codes for these eight cancer groupings are included in Appendix A. These 8 cancer groups are:

a) leukemia, including acute and non-acute lymphocytic types, and chronic myeloid leukemia;

b) lymphoma and other similar neoplasms, including Hodgkin. s disease, non-Hodgkin. s lymphoma, and Burkitt. s lymphoma;

c) tumors of the central nervous system, including miscellaneous intra-cranial and intra-spinal neoplasms (e.g., ganglioglioma), and the sympathetic nervous system (e.g., neuroblastoma);

d) retinoblastoma;

e) renal tumors including the more common Wilms. tumor, as well as rarer diagnoses, such as bone metastasizing renal tumors and rhabdoid renal tumor;

f) malignant bone tumors (e.g., osteosarcoma and Ewing. s sarcoma) and soft tissue sarcomas (e.g., rhabdomyosarcoma, soft tissue Ewing. s tumor, and neurofibrosarcoma);

g) infrequently diagnosed types (including hepatic tumors, germ-cell, trophoblastic and other gonadal neoplasms and other and unspecified malignant neoplasms); and

h) carcinoma and other malignant epithelial neoplasms (e.g., carcinoma of thyroid, nasopharyngeal area and melanoma). (Note: does not include carcinomas of kidney, liver and gonads).

Cancer incidence data for the years 1982-1994 were obtained from the MCR. The MCR has been monitoring cancer incidence in the state of Massachusetts since 1982, with complete data available through 1994 at the time of this evaluation.

In order to calculate incidence rates, it is necessary to obtain accurate population information. The population figures used in this analysis were interpolated based on 1980 and 1990 census data for each town (U.S. Bureau of Census 1980, 1990). To estimate the population between census years, a standard assumption was made that the change in population occurred at a constant rate throughout the ten-year interval between each census. From these calculations, 1987 population estimates were obtained for each town on the Cape.

Standardized Incidence Ratios

In order to evaluate cancer incidence, standardized incidence ratios (SIRs) were calculated for the period 1982 to 1994 for all of Cape Cod, for each of the three Cape regions (Upper, Mid and Lower) and for each town (see Figure 1). An SIR estimates the occurrence of disease in a population relative to what might be expected if the population had the same cancer experience as some larger population designated as "normal" or average. Usually, the state as a whole is selected to be the "normal" or referent population.

Specifically, a SIR is the ratio of the observed number of cancer cases to the expected number of cases multiplied by 100 (the SIR is multiplied by 100 to enable an easily understood percentile and does not reflect the actual number of excess cases). An SIR of 100 indicates that the number of cancer cases observed in the population being evaluated is equal to the number of cancer cases expected in the normal population. An SIR greater than 100 indicates that more cancer cases occurred than expected; an SIR less than 100 indicates that fewer cancer cases occurred than expected. Accordingly, an SIR of 150 is interpreted as 50 percent more cases than the expected number; an SIR of 90 indicates 10 percent fewer cases than expected.

Caution should be exercised, however, when interpreting an SIR. The interpretation of an SIR depends on both the size and the stability of the SIR. Two SIRs can have the same size but not the same stability. For example, an SIR of 150 based on six expected cases and nine observed cases indicates a 50 percent excess in cancer, but the excess is three cases. Conversely, an SIR of 150 based on two hundred expected cases and three hundred observed cases represents the same 50 percent excess in cancer, but because the SIR is based upon a greater number of cases, the estimate is more stable. It is very unlikely that 100 excess cases of cancer would occur by chance alone.

To determine if the observed number of cases is significantly different from the expected number or if the difference may be due solely to chance, a 95% confidence interval (95% CI) is calculated (Rothman and Boice, 1982). A 95% CI is the range of estimated SIR values that have a 95% probability of including the true SIR for the population. If the confidence interval range does not include the value 100, then the study population is statistically significantly different from the "normal" population. A "statistically significant difference" means there is less than five-percent chance that the observed difference is merely the result of random fluctuation in the number of observed cancer cases. For example, if a confidence interval does not include 100 and the interval is above 100, then there is a significant excess in the number of cancer cases. Similarly, if the confidence interval does not include 100 and the interval is below 100, then the number of cancer cases is significantly less than expected. If the confidence interval range includes 100, the true SIR may be 100, and it cannot be concluded with sufficient confidence that the observed number of cases reflects a real cancer excess or deficit. Statistical significance is not assessed when fewer than five cases are observed.

In addition to the number of cases, the width of the confidence interval also reflects the stability of the SIR estimate. For example, a narrow confidence interval (e.g., 103 to 115) allows a fair level of certainty that the calculated SIR is close to the true SIR for the population. A wide interval (e.g., 85 to 450) leaves considerable doubt about the true SIR, which could be much lower than or much higher than the calculated SIR. This would indicate an unstable statistic. In these instances, the number of observed cases is usually small and the difference in the number of observed and expected cases is also small, so chance cannot be ruled out as an explanation for an SIR value that appears elevated.

A wide confidence interval does not necessarily mean that the difference between the observed and expected number of cases may not be important. With additional data in future years, more precise SIR values may be estimated and a more confident determination made on whether incidence is elevated. But lacking precise SIR values, it may be prudent to interpret such SIRs conservatively. On the other hand, additional years of data may suggest that an elevated rate can be attributed to statistical instability. In addition, when doing analyses by town, many SIRs were not be calculated because the number of observed cases were small (i.e. less than 5 cases). Similarly, SIRs for subsets of the 1982 . 1994 period were not calculated because of small numbers. Because cancer occurs rarely among children, the number of observed cases in a small population would likely be small, even if the rate of cancer in the population was higher than the state rate. In this situation, it is extremely difficult to differentiate real differences between observed and expected numbers of cases from differences due to statistical fluctuations. However, even if the observed number of cases for a specific cancer type was too small to calculate an SIR, we calculated the expected number of cases for the specific cancer types and evaluated differences between observed and expected cases.

When evaluating an SIR, it is important to remember that an SIR can only tell us if the cancer incidence is higher or lower than expected for a town or region when compared to the state. An SIR cannot be used to explain why cancer incidence may or may not be elevated.

Geographic Distribution of Cancers

The geographic distribution of childhood cancers was determined using available information on town of residence at diagnosis from the MCR. Information is included for the entire Cape, as well as for the Upper, Mid, and Lower Cape regions (Figure 1). Although issues of patient confidentiality preclude publishing a map of the precise location of the residences of cancer cases, we have presented cancer data and SIRs for each cancer type by sex, town, and region. We also examined the location of cancer diagnoses within towns to search for possible groupings by residence at time of diagnosis.

B. RESULTS

Distribution of Childhood Cancer Incidence on Cape Cod

Sixty-five percent of the 101 cancers diagnosed in Cape Cod children comprised lymphomas, leukemias, or central and sympathetic nervous system tumors (see Table 1). Other cancer types diagnosed among Cape Cod children included soft tissue and malignant bone tumors (N = 10), carcinomas (N = 9), and renal tumors (N= 8).

The number of diagnoses among Cape Cod children was nineteen percent higher than expected (101 observed versus 85 expected; SIR = 119) (see Table 1). This elevation approached statistical significance (95% CI = 97-145). The elevation in total cancer was due to an excess of about 10 cases among female children (SIR = 128, 95% CI = 94-169) and an excess of about 6 cases among male children (SIR =113, 95% CI = 84-147).

Elevations in a few types of cancer were responsible for the elevation in total cancer, specifically elevations in leukemia among male children (16 observed versus about 12 expected), lymphoma among both male (15 observed versus about 8 expected) and female children (11 observed versus about 6 expected), renal tumors among female children (7 observed versus about 2 expected), and carcinomas in female children (7 observed versus about 4 expected). The incidence of lymphomas in male children (95 % CI = 110-324) and of renal tumors in female children (95% CI = 145-744) were statistically significantly elevated compared with the state as a whole.

Distribution of Childhood Cancer in Three Cape Cod Regions

The distribution of cancer incidence among Cape Cod children within each region and town by cancer type and sex was also examined. Examination of cancer incidence within regions and towns provides an opportunity for evaluating cancer types that may not be elevated across the entire Cape.

Leukemias, lymphomas, and central and sympathetic nervous systems tumors also made up 60 percent and 77 percent of total cancer among Upper Cape and Mid Cape children, respectively (see Table 2 and 3). The most frequently diagnosed cancer among the Lower Cape children was leukemia (see Table 4).

The incidence of total cancer occurred about as expected in the Upper Cape region (55 observed versus about 54 expected) (see Table 2). The elevation of the total childhood cancer incidence for Cape Cod as a whole was primarily due to an elevation among children in the Mid (35 observed versus about 25 expected; SIR = 143, 95% CI = 100-199) and Lower Cape regions (11 observed versus about 7 expected; SIR = 163, 95% CI = 81-292) (see Tables 3 & 4).

Upper Cape Cod Children - Barnstable, Bourne, Falmouth, Mashpee, Sandwich

The incidence of total cancer was about as expected among Upper Cape children, with slight elevations in lymphomas among males, renal tumors among females, and carcinomas among females (Table 2). Seven lymphomas occurred among male children versus about 5 expected. The Upper Cape elevation in lymphomas among males did not appear to be due to elevations in any particular town, with 2 cases each in Barnstable, Bourne, and Falmouth; one case in Mashpee, and no cases in Sandwich (see Appendix B).

Female children experienced an excess of two to three carcinoma diagnoses (5 observed versus 2-3 expected). Three of the 5 carcinoma cases among females on the Upper Cape were residents of Falmouth , an excess of about 2 cases for this town (see Appendix B). Three cases of renal tumors occurred among females on the Upper Cape versus about one expected, with one case occurring in each of Barnstable, Mashpee, and Sandwich.

Among individual towns, leukemia among males in Barnstable was slightly elevated (5 observed versus about 3 expected), as was central and sympathetic nervous system tumors among males in Sandwich (3 observed versus about 1 expected).

Mid Cape Children - Brewster, Chatham, Dennis, Harwich, Yarmouth

As mentioned above, the elevation in total cancer across Cape Cod was primarily attributable to an elevation that nearly achieved statistical significance in total cancer among children in the Mid Cape region (Table 3). The elevation in total cancer in the Mid Cape region affected both males and females. Among female children, 17 total cancers were observed versus 11 expected (95% CI = 90-248), and among male children, 18 were observed and about 14 expected (95% CI = 79-211). At the town level, all five mid-Cape towns had about 1 or 2 excess cases of cancer among females (see Appendix B). Among males, Harwich experienced three to four excess cases, while the other four towns experienced about 1 or 2 excess cases among male children.

The elevation in total cancer across the Mid Cape was primarily explained by statistically significant elevations in lymphomas in males (7 observed versus about 2 expected; SIR = 317, 95% CI = 127-653) and females (6 observed versus about 2 expected; SIR = 351, 95% CI = 128-765); and by an elevation in leukemia among males (6 observed versus about 3 expected; SIR = 176, 95% CI = 64-384) (see Table 3). Female children in the Mid Cape region also experienced slight excesses in renal tumors (3 observed versus less than one expected) and in cancers of the central and sympathetic nervous systems (5 observed versus about 3 expected).

Seven of the 9 excess cases of lymphoma among mid-Cape children occurred in the towns of Brewster (3 observed versus about 1 expected) and Yarmouth (6 observed versus about 1 expected). Lymphoma incidence among Yarmouth children was statistically significantly elevated compared to that of Massachusetts children (SIR = 438, 95% CI = 160-953) with the excess cases being spread evenly between male and female children (3 observed versus about 1 expected for each sex).

The excess cases of leukemia among Mid Cape males and renal tumors among females were observed across the towns of Dennis, Harwich and Yarmouth, with each town experiencing about one excess case of each type of cancer. Each of the five Mid Cape towns had one female diagnosed with a central or sympathetic nervous system tumor.

Lower Cape Children - Eastham, Orleans, Provincetown, Truro, Wellfleet

Eleven Lower Cape children were diagnosed with cancer, versus about 7 expected (see Table 4). The incidence of total cancer was slightly elevated among both male (6 observed versus about 4 expected) and female children (5 observed versus 3 expected) in the Lower Cape region. Neither elevation achieved statistical significance.

The Lower Cape elevation in total cancers was attributed primarily to excess diagnoses among Eastham children (6 observed versus about 2 expected) (see Appendix B). This elevation was statistically significant (SIR = 312, 95% CI = 114-679). Although an SIR could not be generated for most cancer types as a result of a small number of cases in this region, the excess in total cancer among Lower Cape children was attributable in part to a slight excess in the number of leukemias in this region (4 observed versus about 2 expected). All four leukemia cases occurred among Eastham children and the excess was among both male and female children in Eastham (2 observed versus less than 1 expected for each sex).

Geographic Distribution

We examined the geographic distribution of case residences below the town level for all cancer types throughout Cape Cod. No apparent geographic concentration of cases below the town level was found for any cancer type. However, this descriptive study was limited in that analysis was based on residence at the time of diagnosis.

III. DISCUSSION

Overall, Cape Cod experienced a 19 percent excess of childhood cancers compared with the statewide experience. About 10 excess cases occurred among females, while about 6 excess cases occurred among males. Capewide, statistically significant elevations were seen for lymphomas among males and renal tumors among females. The incidence of lymphomas among females was nearly statistically significantly elevated across the entire Cape. Also elevated Capewide were leukemias among males and carcinomas among females but neither of these elevations were statistically significant.

When examined by region, the Upper Cape generally experienced cancer rates that were about as expected. When excesses occurred among males or females for specific cancer types, the excesses were generally of one or two cases. The exception was for carcinomas among females, where five cases among Upper Cape females occurred versus 2-3 expected.

The Capewide elevation in total cancer incidence was attributable primarily to elevations among Mid Cape and Lower Cape children. In the Mid Cape region, lymphomas among males and among females were both statistically significantly elevated. When examined by town in the Mid Cape, Yarmouth children experienced a statistically significant elevation in lymphoma incidence, with the excess cases spread evenly among both males and females. Brewster also experienced an elevation of lymphoma.

The six Yarmouth lymphomas were evaluated in greater detail to determine if characteristics of the cases might suggest a common cause. The assessment revealed that only two of the cases were known to be residents of Yarmouth at time of birth. This indicates that a common exposure at time of birth is not a likely explanation for the cancers.

Because some researchers have proposed an infectious agent as a cause of some type of lymphoma, the dates of birth and place of residence were examined for the cases. The dates of birth were found to be between 1965 and 1984 with each case having a different birth year. Place of residence also was not similar. Common dates of birth or multiple cases in the same family would have been expected if an infectious agent played a role in these cancers. Finally, each type of lymphoma was identified and five or the six cases had a different histologic type of lymphoma. This suggests that the cause of the cancers may be different.

Other cancer types that were slightly elevated in the Mid Cape region included leukemia among males, renal tumors among females, and central/sympathetic nervous system tumors among females. Excesses in these cancer types were generally distributed evenly among the Mid Cape towns.

In the Lower Cape region, the elevation in total cancer incidence among children was attributable primarily to a statistically significant elevation in total cancers among Eastham children (6 observed versus about 2 expected). Four of these cancers were leukemias, which were the only leukemia cases among Lower Cape children. The excess of leukemia among Eastham children was spread evenly among males and females, with each sex experiencing 2 cases versus less than 1 expected.

As noted earlier, the incidence of renal tumors among female children Capewide was statistically significantly elevated compared with the statewide experience. Of the seven observed cases, three occurred in each of the Upper and Mid Cape regions (versus about 1 or less expected), while one case occurred in the Lower Cape. No individual community on Cape Cod accounts for this excess as each community had no more than one female diagnosed with renal cancer during this time period.

The geographic distribution of cases within each town was also examined. Residence at the time of diagnosis was mapped for all children diagnosed with cancer. No apparent geographic concentration of cases below the town level was found for any cancer type.

The following sections discuss in more detail the occurrence of selected cancer types. The interpretation of these data is limited by the lack of information on factors such as length of residence and previous Cape residences and proximity to areas that may offer the potential for environmental exposures (e.g., power lines, hazardous waste sites). The data can be interpreted for current geographic patterns or possible clusters. However, given the limitations noted previously regarding residential history, these types of geographic patterns would warrant further evaluation.

Leukemia

Leukemia diagnoses on Cape Cod were distributed by age, sex ratio and histological type in a manner similar to what is seen nationwide. The majority of leukemia cases (69 percent) among children on Cape Cod were diagnosed among male children. This difference in sex ratio is not unexpected, since leukemia normally occurs more frequently among boys than girls in the United States (SEER 1997).

Although leukemia among males was elevated in the Mid Cape region, the patterns of type of leukemia and age at diagnosis were not unusual. Leukemia cases in the Mid Cape region were not grouped by a particular age or year of diagnosis. The majority of mid-Cape children diagnosed with leukemia had Acute Lymphocytic Leukemia (ALL), the most commonly diagnosed histological type among United States children (see Appendix C for discussion of subtypes of leukemia).

All 4 leukemia cases on the Lower Cape occurred in Eastham. Eastham children diagnosed with leukemia were not grouped by a particular age or year of diagnosis. Again, the majority of leukemia cases were of the histological type ALL.

Lymphomas

The category lymphoma can be broken up into several subtypes, including Hodgkin. s disease, non-Hodgkin. s lymphoma, and Burkitt. s lymphoma. The subtypes Hodgkin. s disease and non-Hodgkin. s lymphoma are the most frequently diagnosed lymphomas among United States children.

Similarly, the subtypes of lymphoma most frequently diagnosed on Cape Cod were Hodgkin. s disease and non-Hodgkin. s lymphoma (see Appendix C for discussion of risk factors). In the U.S., Hodgkin. s disease is also diagnosed more frequently in male children than in female children. On Cape Cod, slightly more Hodgkin. s disease cases were diagnosed among females than males (9 females, 7 males).

Hodgkin. s disease is made up of several different histological types. The most common histological types diagnosed among U.S. children are nodular sclerosis and mixed cellularity. Cape Cod children followed this general pattern with the majority of histologies in Hodgkin. s disease cases being either nodular sclerosis or mixed cellularity (one diagnosis was nonspecific).

The histological type is important because Hodgkin. s disease is thought to have two separate etiologies related to histological subtype and age at time of diagnosis. In the U.S., the incidence of Hodgkin. s disease is low in children younger than 10 years of age and then increases rapidly in 15 to 39-year olds (see Appendix C). The incidence of the disease then drops off until a second peak is seen among the elderly. The incidence of Hodgkin. s disease was elevated among children on the Cape, but the distribution of age at diagnosis was very similar to that occurring in the rest of the country.

Hodgkin. s disease diagnoses were spread over the 1982-1994 time period for Cape Cod children. Males and females did not differ by their mean year of diagnosis or their age at diagnosis. Due to the limited number of observed cancers, it was not possible to determine if any pattern exists relative to the year of diagnosis in other Cape Cod regions.

The other common lymphoma on Cape Cod and in the United States was non-Hodgkin. s lymphoma. On Cape Cod, non-Hodgkin. s lymphoma cases were not grouped by a particular age or year of diagnosis, with the exception of the town of Yarmouth where all three non-Hodgkin. s lymphoma cases were diagnosed in 1991. However, these 3 NHL cases all had different histologic types. Roughly three quarters of non-Hodgkin. s lymphoma on Cape Cod occurred among male children, which was also not unexpected since, in the United States, males generally are diagnosed with lymphomas more often than females (Scherr and Mueller, 1996; SEER 1997). Again, although non-Hodgkin. s lymphoma is elevated on the Cape, the distribution of the diagnoses by age, sex and year of diagnosis was not unusual.

Renal Tumors

Renal tumors are similarly divided up into several sub-categories, including Wilm's tumor, rhabdoid and clear cell sarcomas, and renal cancers. All of the renal tumors diagnosed among Cape Cod children were of a subtype called Wilm's tumor, the most commonly diagnosed renal tumor among children in the U.S. The preponderance of Wilm. s tumor diagnoses among female children (7 of 8 renal tumors occurred in females) on Cape Cod is similar to the experience elsewhere in the U.S., where renal cancers are diagnosed more frequently among females than among males (Schottenfeld and Fraumeni, 1996).

Carcinomas

Carcinoma was elevated (4 observed versus about 1 expected) in the Upper Cape town of Falmouth. The carcinoma diagnoses in Falmouth were primarily made up of malignant melanomas, a cancer that is not diagnosed commonly among children in the United States. However, melanoma was also elevated among adults on the Upper Cape (see Upper Cape Cancer Incidence Review 1986-1994, 1982-1990, MDPH, 1997). No particular temporal or spatial pattern was observed among children diagnosed with melanoma on the Upper Cape. The majority of cases in the Upper Cape region were in their mid teens, however, this variability is difficult to evaluate due to the small number of individuals diagnosed.

IV. CONCLUSIONS

This evaluation of childhood cancer incidence on Cape Cod revealed several cancer types that were elevated either Capewide or in certain towns. It did not reveal unusual spatial, temporal, or other (e.g., age at diagnosis, histological type) patterns within any specific town on the Cape that might suggest a common environmental link.

- From 1982-1994, Cape Cod children experienced nineteen percent more total cancer than expected compared to the statewide experience in Massachusetts. s children.

- The elevation in total cancer for Cape Cod was primarily attributable to cancers diagnosed among Mid-Cape children and, to a lesser extent, Lower Cape children.

- While based on small numbers, statistically significant elevations were observed for lymphomas among males and renal tumors among females across Cape Cod. The incidence of lymphomas among females was nearly statistically significantly elevated. No individual community on Cape Cod accounts for this excess as each community had no more than one female diagnosed with renal tumor, thereby indicating no particular spatial pattern of this cancer type.

- Cancer incidence on the Upper Cape occurred about as expected, with small elevations in carcinoma among females and lymphoma among males.

- The Mid-Cape elevation was primarily attributable to a statistically significant elevation in the incidence of lymphoma in both males and females and to a nonstatistically significant elevation in leukemia among males.

- The Mid Cape elevation in lymphoma incidence was due in part to a statistically significant elevation in lymphoma incidence among Yarmouth children. However, no unusual pattern was evident among these Yarmouth children in terms of histologic type, age distribution, and year of diagnosis. Most of these children were not residents of Yarmouth at the time of birth.

- Total cancer was elevated in Lower Cape children, due primarily to an elevation in the incidence of leukemia in the town of Eastham (4 observed, 0.5 expected). The incidence of leukemia among Eastham children did not show spatial or temporal patterns that might suggest a common link. The majority of leukemia cases were of the histologic type, ALL, which is the most commonly diagnosed histologic type in children.

- The elevations of cancer on the Cape did not appear to concentrate in specific areas within towns or by a specific time period. With the exception of an unusual sex ratio for Hodgkin. s disease, the sex ratios and age distribution of cancers were not unusual. Similarly, the histological types of the cancers diagnosed to Cape Cod children were not unusual.

V. RECOMMENDATIONS

Very little is known about the etiology of childhood cancers, which are rare diseases. For this reason it is important that the MDPH involve the local medical community in discussions about elevated rates of various childhood cancers and possible etiological factors. Based on the findings described in this report, MDPH staff should (1) conduct health professional outreach activities (e.g., Grand Rounds) in Cape Cod health care facilities to increase awareness among the local medical community of the findings of this descriptive evaluation, and (2) continue to monitor and evaluate cancer incidence and trends among children on Cape Cod through the Massachusetts Cancer Registry.

VI. REFERENCES

American Cancer Society 1996. Cancer Manual, 9th ed. American Cancer Society, Massachusetts Division, Boston MA.

American Cancer Society 1995. Cancer Facts and Figures - 1995. American Cancer Society, Atlanta Georgia.

American Cancer Society 1990. Cancer Manual, 8th ed. American Cancer Society, Atlanta Georgia.

Birch JM, Hartley AL, Teare MD, et al. 1990. The Inter-Regional Epidemiologic Study of Childhood Cancer (IRESCC): Case control study of children with central nervous system tumors. British J Neurosurg 4:17-26.

Birch JM and Marsden HB. 1987. A classification scheme for childhood cancer. Int J Cancer 40(5): 620-624.

Bleyer W 1990. The impact of childhood cancer on the United States and the world. CA 57:1225-1229.

Bogger-Goren S, Zaizov R, Vogel R et al 1983. Clinical and virological observations in childhood Hodgkin. s disease in Israel. Isr J Med Sci 19:989-991.

Breslow N, Olshan A, Beckwith JB, et al 1994. Ethnic variation in the incidence, diagnosis, prognosis, and follow-up of children with Wilms. tumor. Journal of the National Cancer Institute 86:49-51.

Bunin GR, Cramer S, Marrero O et al. 1987. Gestational risk factors for Wilms. tumor: results of a case control study. Cancer Res 47:2972-2977.

Bunin GR, Ward E, Kramer S, et al. 1990. Neuroblastoma and paternal occupation. Am J Epi 131:776-780.

Bunin GR, Nass CC, Kramer S, et al 1989. Parental occupation and Wilms. tumor: results of a case-control study. Cancer Research 49:725-729.

Bunin GR, Kuijten RR, Boesel CP, et al 1994. Maternal diet and risk of astrocytic glioma in children: a report from the Children. s Cancer Group. Cancer Causes Control 5:177-187.

Chow WH, Linet MS, Liff JM, Greenberg RS 1996. Cancers in Children. In: Cancer Epidemiology and Prevention. Schottenfeld D and Fraumeni JF (eds). New York: Oxford University Press.

Farwell P and Flannery JT 1984. Cancers in relatives with central nervous system neoplasms. New England Journal of Medicine 311(12):453-479.

Filippini G, Farinotti M, Lovicu G, et al 1994. Mothers. active and passive smoking during pregnancy and risk of brain tumors in children. International Journal of Cancer 57:769-774.

Freedman A and Hadler L 1994. Malignant Lymphomas. In: Harrison. s Principles of Internal Medicine, 13th ed., vol. 2. Isselbacher et al eds. New York: McGraw-Hill Inc.

Giuffre R, Liccardo G, Pastore FS, et al 1990. Potential risk factors for brain tumors in children. Childs Nervous System 6:8-12.

Gold E, Gordis L, Tonascia J, et al 1979. Risk factors for brain tumors in children. American Journal of Epidemiology 109:309-319.

Golde D and Guliti S 1994. The Myeloproliferative Disease. In: Harrison. s Principles of Internal Medicine. 13 ed., vol. 2. Isselbacher, et al eds. New York: McGraw-Hill Inc.

Goldhaber MK, Selby JV, Hiatt RA, et al 1990. Exposure to barbiturates in utero and during childhood and risk of intracranial and spinal cord tumors. Cancer Research 50:460--4603.

Gutensohn N and Cole P 1981. Childhood social environment and Hodgkin. s disease. New England Journal of Medicine 304:135-140.

Higginson J, Muir C, and Munoz N 1992. Cambridge Monographs on Cancer Research. Human Cancer: Epidemiology and Environmental Cuass. Cambridge, England: Cambridge University Press.

International Agency for Research on Cancer, June 1997 meeting monograph.

Jankovic M, Masera G, Cristiani ML, et al 1991. Brain tumors as second malignancies in children treated for acute lymphoblastic leukemia. Neuro Oncol 66: 365-369.

John EM, Savitz DA, Sandler DP 1991. Prenatal exposure to parents. smoking and childhood cancer. American Journal of Epidemiology 133:123-132.

Johnson CC and Spitz MR 1989. Childhood nervous system tumors: an assessment of risk associated with paternal occupations involving use, repair or manufacture of electrical and electronic equipment. International Journal of Epidemiology 18: 756-762.

Kantor AF, McCrea, Curnen MG, Meigs JW, et al 1979. Occupations of fathers of patients with Wilms. tumor. J Epidemiol Community Health 33:253-256.

Kuijten RR, Bunin GR, Nass CC, et al 1990. Gestational and familial risk factors for childhood astrocytoma: results of a case-control study. Cancer Research 50:2608-2612.

Linet MS 1985 . The Leukemias: Epidemiological Aspects. Monographs in Epidemiology and Biostatistics. New York: Oxford University Press.

MacMahon B 1966. Epidemiology of Hodgkin. s Disease. Cancer Research 26:1189-1200. Cited in Mueller, 1996.

Massachusetts Department of Public Health, 1998. Upper Cape Cancer Incidence Review, 1986-1994, Final Report. Bureau of Environmental Health Assessment.

Massachusetts Department of Public Health, 1995. Upper Cape Cancer Incidence Review, 1982-1990 Final Report. Bureau of Environmental Health Assessment.

Massachusetts Department of Public Health, 1997. Woburn Childhood Leukemia Follow-Up Study. Bureau of Environmental Health Assessment.

Mauron FB, Jacob JC, Heneghan WD, Magnan MA, et al 1984. Familial intracranial gliomas. Surg Neurol 22(1):76-78.

McCredie M, Maisonneuve P, Boyle P 1994. Antenatal risk factors for malignant brain tumors in New South Wales children. International Journal of Cancer 56: 6-10.

Miller BA, Ries LAG, Hankey BF et al (eds.) 1993. SEER Cancer Statistics Review: 1973-1990. National Cancer Institute. NIH Publication No. 93-2789.

Modan B, Baidatz D, Mart H, et al 1974. Radiation-induced head and neck tumors. Lancet 1: 277-279.

Mueller NE 1996. Hodgkin. s Disease. In: Cancer Epidemiology and Prevention. 2nd Edition. Schottenfeld D and Fraumeni JF (eds). New York: Oxford University Press.

Nasca PC, Baptiste MS, MacCubbin PA, et al. 1988. An epidemiologic case-control study of central nervous system tumors in children and parental occupational exposures. Am J Epidemiol 128: 1256-1265.

Olsen JH, Brown P, Schulgen G, et al 1991. Parental employment at time of conception and risk of cancer in offspring. Eur J Cancer 27:958-965.

Olshan AF, Breslow NE, Falletta JM, et al 1993. Risk factors for Wilms. tumor - Report from the National Wilms Tumor Study. Cancer 72:938-944.

Page HS and Asire AJ 1985. Cancer Rates And Risks. 3rd ed. Washington DC: National Institutes of Health Publication No. 85-691.

Parkin DM Stiller CA Draper GJ et al (eds.) 1988a. International Incidence of Childhood Cancer. IARC Scientific Publications No. 87. Lyon, International Agency for Research on Cancer (IARC).

Parkin DM, Stiller CA, Draper GJ, et al 1988b. The international incidence of childhood cancer. Int J Cancer 42: 511-520.

Preston-Martin S, Yu MC, Benton B, et al 1982. N-Nitroso compounds and childhood brain tumors: a case-control study. Cancer Res 42:5240-5245.

Preston-Martin S and Henderson BE 1984. N-Nitroso compounds and human intracranial tumors. In: N-Nitroso Compounds: Occurrence, Biological Effects and Relevance to Human Cancer. O. Neil IK, von Borstel BC, Miller CT, et al (eds.). IARC Scientific Publication No. 57. Layon, IARC, pp. 887-894.

Razzouk BI et al. 1997. Epstein Barr virus in pediatric Hodgkin. s Disease: Age and histiotype are more predictive than geographic region. Med. and Ped. Oncology 28: 248-254.

Rothman KJ and Boice JD 1982. Epidemiologic Analysis with a Programmable Calculator. Boston: Epidemiology Resources Inc.

Salcman M and Soloman L 1984. Occurrence of glioblastoma multiforme in three generations of a cancer family. Neurosurgery 14(5):557-561.

Sarasua S and Savitz DA 1994. Cured and broiled meat consumption in relation to childhood cancer: Denver, Colorado. Cancer Causes Control 5:141-148.

Scheinberg D and Golde D 1994. The Leukemias. In: Harrison. s Principles of Internal Medicine. 13th ed., vol. 2. K. Isselbacher et al (eds.). New York: McGraw-Hill Inc.

Scherr PA and Mueller NE 1996. Non-Hodgkin. s Lymphoma. In: Cancer Epidemiology and Prevention. 2nd Edition. Schottenfeld D and Fraumeni JF (eds). New York: Oxford University Press.

Schottenfeld D and Fraumeni JF 1996. Cancer Epidemiology and Prevention. 2nd Edition. New York: Oxford University Press.

Schwartzbaum JA, George SL, Pratt CB, et al 1991. An exploratory study of environmental and medical factors potentially related to childhood cancer. Med Pediatr Oncol 19:115-121.

SEER 1997 Web Site Data Set.

Siegel M 1993. Smoking and Leukemia: Evaluation of a Causal Hypothesis. American Journal of Epidemiology 138(1).

Spitz MR and Johnson CC 1985. Neuroblastoma and paternal occupation: a case-control analysis. American Journal of Epidemiology 121:924-929.

Stiller CA and Parkin DM 1990. International variations in the incidence of childhood renal tumors. British Journal of Cancer 62:1026-1030.

US Bureau of Census 1980. 1980 Census Population: General Population Characteristic, Massachusetts. US Department of Commerce, Washington DC.

US Bureau of Census 1990. 1990 Census Population: General Population Characteristic, Massachusetts. US Department of Commerce, Washington DC.

Wilkins JR and Sinks T 1990. Paternal occupation and intracranial neoplasms of childhood: results of a case-control interview study. American Journal of Epidemiol 132:275-292.

Wilkins JR and Sinks T 1984a. Parental occupation and Wilms. tumor in offspring. Jour Epidem Comm Health 38:7-11.

Wilkins JR and Sinks T 1984b. Occupational exposures among fathers of children with Wilms. tumor. Journal of Occupational Medicine 26:427-435.

Young JL Jr, Gloeckler Reis L, Silverberg E, et al. 1986. Cancer incidence, survival and mortality for children younger than age 15 years. Cancer Suppl 58:598-602.